

Saskatchewan Technology Enhancement Program

Salinity Area Identification and Mapping Within the South Saskatchewan River Irrigation District #1

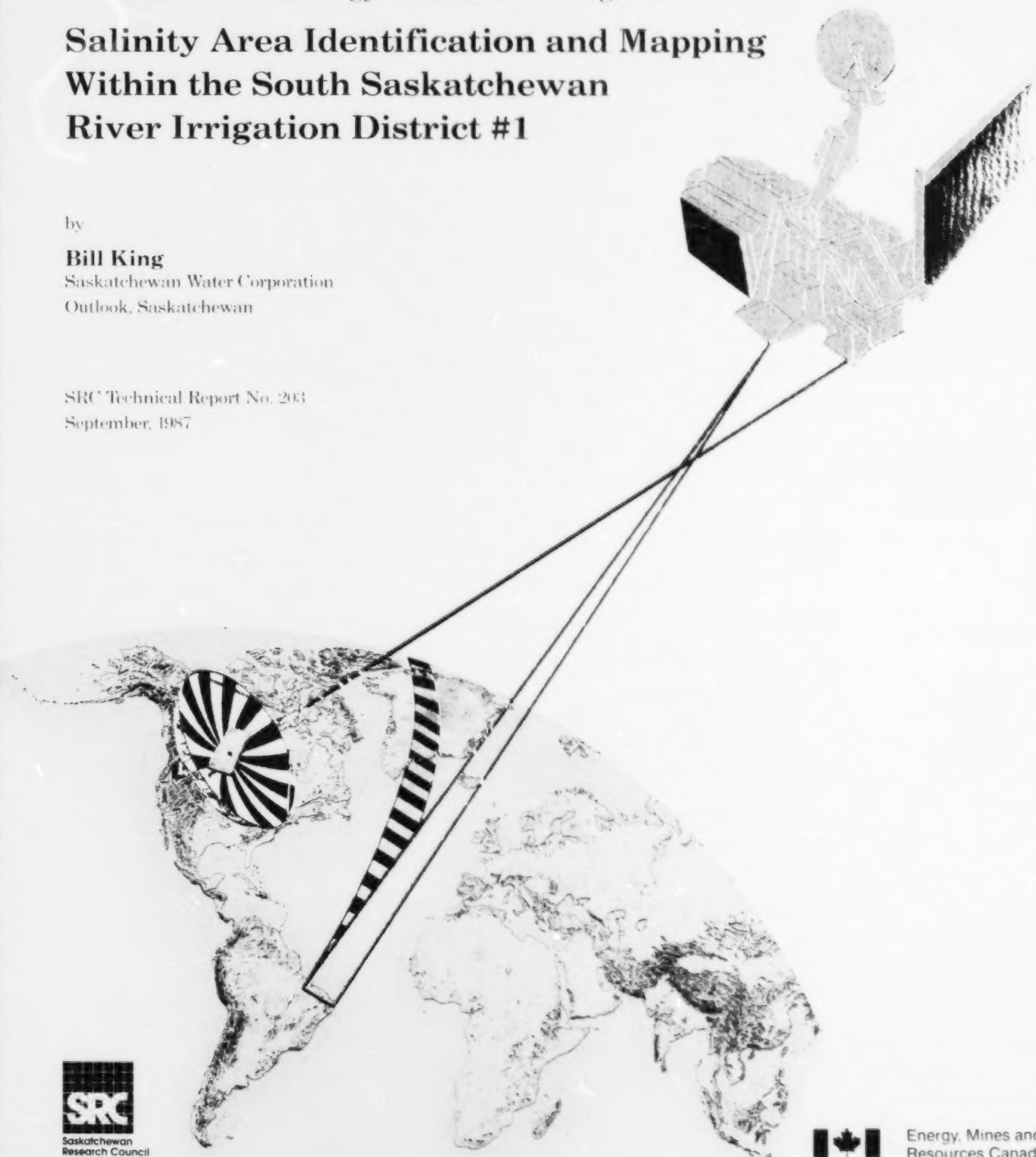
by

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SRC Technical Report No. 203

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Saskatchewan Remote Sensing Centre

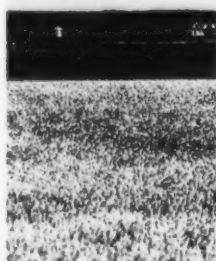
Predicting Good Grain Crops

Irrigated Areas

Arid Zone Surveys

Crop Locations and Identification

Soil Salinity



How remote sensing can work for you

- *measure crop response to fertilizer*
- *detect uneven nozzle distribution of water, fertilizers and herbicides*
- *detect poor yields due to salinity, weeds, excess herbicide application in previous years, poor drainage*
- *quickly determine area estimation of yield and seeded crops*
- *plan for exact seed, fertilizer and chemical inputs*
- *cost effective 22:1 over traditional methods*

Agriculture

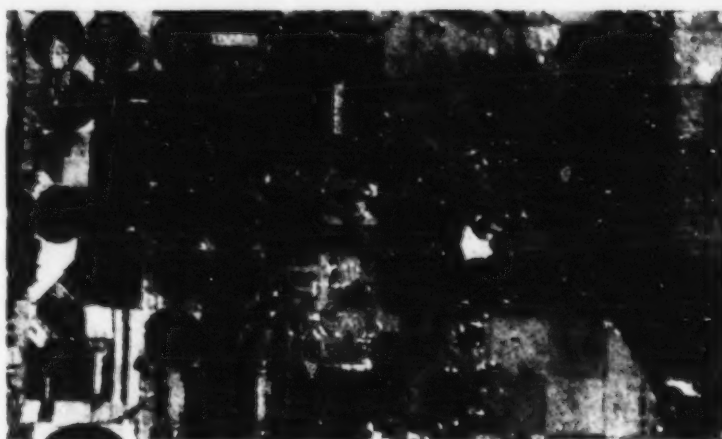


Photo 1



Photo 2

Photo 1 - Salinity detection in irrigation (red - saline areas) at Outlook, Saskatchewan.
(Courtesy of Saskatchewan Agriculture, Irrigation Branch).

Photo 2 - Drought index of Saskatchewan for 1985 (red - 50-97% loss of yield; light green - 50% loss of yield; dark green - normal yield).



Saskatchewan
Research Council

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WITHIN THE SOUTH SASKATCHEWAN RIVER
IRRIGATION DISTRICT #1**

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1. INTRODUCTION

This Chapter has been abstracted from Jealous (1987).

Excess soil salinity affects vast areas of the Great Northern Plains particularly parts of Alberta, Saskatchewan, Manitoba, Montana, North Dakota and South Dakota. Figure 1 illustrates the extent of areas which are moderately to severely affected. It is estimated that approximately 2,000,000 ha of cultivated land in the province of Saskatchewan area affected by dryland salinity and of this ap-

proximately 400,000 ha are severely affected (Holm and Henry 1982).

When the salinity of a soil reaches a point where its pH is close to or higher than that of the plants roots the osmotic pressure is reduced and plant growth may be affected in moderate cases or the plant may wilt and die in severe cases. Saline soils can reduce crop yields by 5 to 100% of normal, therefore identifying affected soils or potentially affected soils is an important first

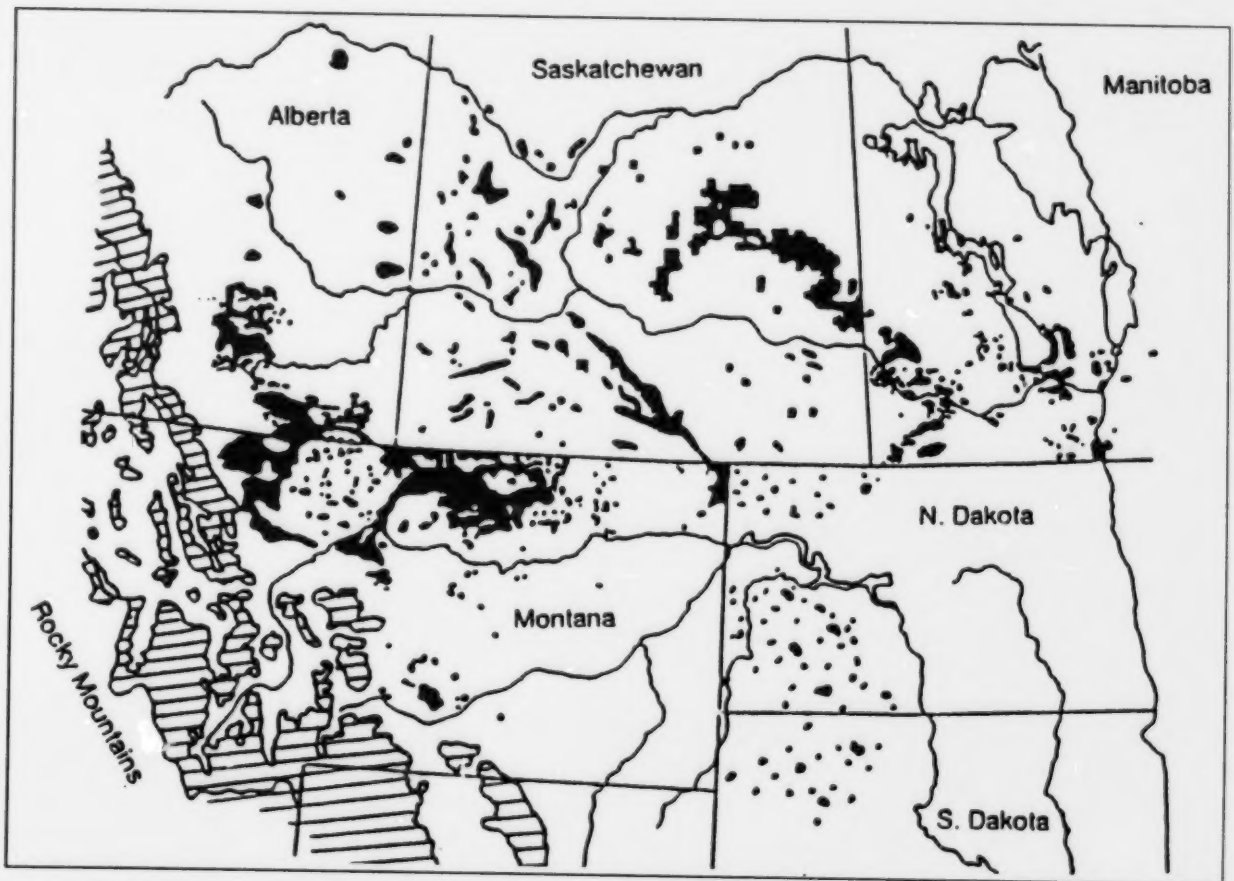


Figure 1. Areas in the Northwestern Great Plains Region affected by dryland salinity. (After Holm and Henry, 1982)

step in attempting to control their spread to productive areas.

On the prairies, saline soils develop in areas where drainage is restricted and glacial deposits are relatively thin. The semi-permeable glacial deposits are underlain by impermeable salt laden shales. The lower glacial tills which were primarily derived from these shales also contain high concentrations of salts while overlying tills and glaciolacustrine deposits comprise the parent material for the productive agricultural soils which exist over most of the prairies. During fallow seasons and periods of high rainfall or irrigation, excess water percolates down to the impervious shales or lower tills, picking up salts as it enters the groundwater system. During hot, dry periods of low rainfall, water which discharges naturally into low areas as well as water brought to the surface by evapotranspiration is lost to the atmosphere leaving behind the salts that were accumulated in the groundwater. Zones where saline groundwater discharges either directly from springs or indirectly by evapotranspiration are termed saline seeps. Saline seeps evolve

through a series of developmental stages defined by Dalsted et al. (1979);

1. incipient or immature stage, indicated by wetness but not excess salinity,
2. intermediate stage, indicated by salt tolerant vegetative species and excess wetness, and
3. mature seeps indicated by salt crusts and excess wetness.

Detection of mature seeps has been successfully accomplished using color infrared photography, Dalsted et al. (1979) and Landsat imager, Thompspon et al. (1981). The stark contrast between the bright white salt accumulations and the surrounding soils is the major recognition factor. Immature or incipient seeps are areas where groundwater is discharging but salt accumulation has not reached the point where crop yields are severely affected.

Delineation of incipient seeps is potentially more beneficial than recognition of mature seeps because once identified corrective farming practices can be used to impede the development of severe salinity problems.

2. PROJECT OBJECTIVES

The objectives of this project were:

1. To identify and map the area of reduced crop production caused by high salinity levels on irrigated land in the South Saskatchewan River Irrigation District #1.
2. Investigate the potential uses of satellite data as an information source imagery to assist in irrigated crop production and policy development.

3. STUDY AREA

The study area was a 20,000 ha irrigation project located on the east side of the South Sas-

katchewan River approximately 100 km south of Saskatoon (Figure 2).

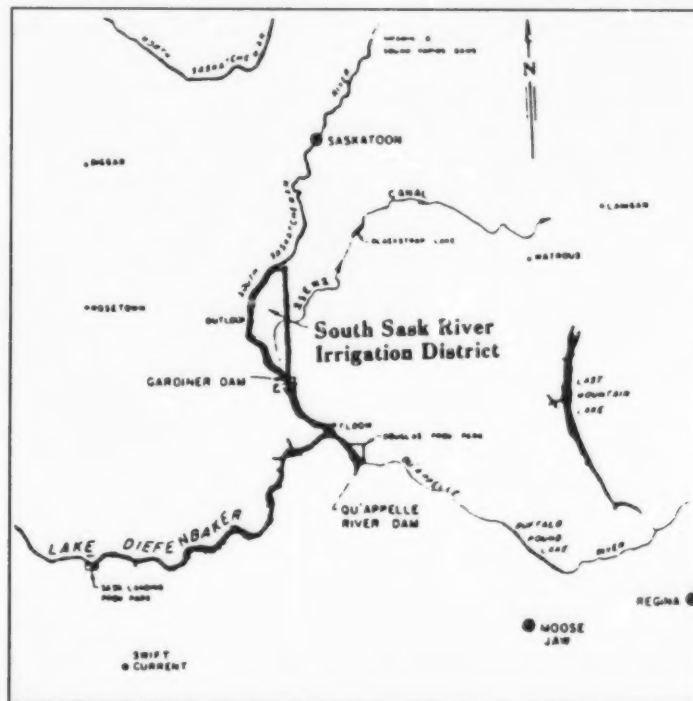


Figure 2. Study Area.

4. DATA SOURCE

The source of data for this project was a Thematic Mapper image from path 37 row 24 taken in July of 1984. Subareas from quadrat one and three were used in the project

The images obtained from the enhancement of this data were compared to low attitude infrared photographs taken in July 1982 and July 1985.

5. METHODOLOGY

The first step in our project was to create a subarea covering as much of the study area as was possible in quadrature one. This subarea was then geometrically corrected to a UTM grid for six high resolution channels of the Thematic Mapper (TM) data and saved on computer tape to be used as the base information for further study.

A subsubarea of approximately 10 km² as created to reduce image decimation and to reduce the time necessary to carry out further procedures. This smaller area was used in a more or less random search of the available data enhancement techniques to determine which tasks highlighted known saline areas.

Each channel of geometrically corrected data covering the small area was viewed on the monitor individually and in combination with each other channel. The subarea image was then enhanced through Boxcar filtering task. Both high pass and directional filtering was carried out on all six channels. The resulting files were combined in various combinations with the unfiltered files and with the enhanced files.

This activity enabled us to show improved resolution of field boundaries, road ways, canals, etc., but did not prove beneficial in identifying saline areas.

We then attempted to highlight the areas of high and low vegetation using arithmetic combination through task NO. Task NO provides seven functions of which five were tried. The options showing the most promise were product, sum difference minus sum and difference over sum (vegetative index).

The vegetative index option formula below gave the most promising visual results.

$$Fo = [(Fi - Fii)/(Fi - Fii) + Ki + Kii]$$

where: Fo = output feature
Fi + Fii = input feature
Ki = offset
Kii = gain

The offset and gain are scaling values used to ensure that the output feature values be within the intensity range 0 to 255 and having a mean of 128 and a standard deviation of 35.

The maximum visual delineation of the target area occurred using channel 4 as Fi and channel 3 as Fii. Similar results but with differing output color came from using channel 1 and 4 respectively.

The two vegetative index files were then combined in various combinations with the unfiltered channels and a visual interpretation of the results obtained.

The combination NOC2 + CHN1 + CHN7 put through task ID in that order gave excellent visual crop separation and showed the target saline area clearly. There was sufficient similarity between the saline area and dry uncultivated areas to cause confusion.

Using the second vegetative index file (NOC3) resulted in good separation of the target area but with less crop differentiation and less confusion with non-target area.

Many other channel combinations both with raw data and filtered data were tried but none appeared to give better results.

Following the decision to use the combination shown above we attempted a supervised classification using task IT followed with a principle component enhancement task IE.

Crop classification accuracy was quite high. Visual estimation about 75% of the crop area in the test classification was classified correctly on a single pixel level. Averaged over an entire field the classification would have been well above 90%. (Note that this result is on an image where crop separation was not the objective.)

The accuracy of salinity classification was very low, 20 to 30% at best. Errors in classifying non saline areas as saline predominate, but there were also known saline areas that did not show up.

At this point we tried an unsupervised classification using task UC. The results of this procedure were more promising than those of the supervised classification but still not of a level that justified additional work.

The final procedure carried out was to make a film positive transparency of the test area using task QC. This product was then compared to low

level infrared photographs to determine how well we could identify saline areas using the satellite imagery. Large areas, 5 ha or greater, or very severe salinity showed up quite well. Accuracy was visually estimated to be over 90%. Smaller areas, those with low to moderate salinity, were often missed.

6. CONCLUSION

The first objective, to identify and map the area of reduced crop production due to salinity was not met by means of the digital image analysis techniques. We had hoped to obtain output data that would show the areas classified as saline and sum the total area involved. The results were not of suitable accuracy to even attempt this objective.

The results were sufficiently accurate using qualitative methods to provide visual interpretation at a level similar to low aerial photography. The satellite covers a much larger area for less money.

The time available for this study as well as the knowledge and skill of the operators was less than adequate to do a comprehensive study of salinity mapping.

The second objective, that of investigating the potential use of satellite imagery in preparing crop production estimates and policy develop-

ment was more successful. Much experience was gained in the use and capabilities of the system. While no specific projects have been identified at this time the potential of the system was certainly proven. Projects involving large land areas without great detail would suit this system very well. Production decisions on an individual farm would likely be better served through aerial photography.

A large amount of training time was spent on unproductive combinations and procedures and on learning to use the system. A cost/benefit projection is therefore difficult. The time spent on this project would approach 200 man hours over a 2 year period. I estimate the time required to duplicate the results would be in the range of 40 hours. Whether an area of 100 km² is used, or one many times larger, the operator time would be about the same.

7. REFERENCES

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